A message from your

Missouri Public Service Commission

Energy Department

What's all this about Stray Voltages?

Voltage is a measureable potential difference between two points. It has to do with the concentration and flow of electrons between those two points. Whether it's dangerous or not has to do with the value of the voltage and the available electron supply for a current flow. Voltage is essentially the force that pushes electrons, and current is the movement of those electrons.

If you've ever walked across a rug and then gotten a brief shock when you touched something metal like a doorknob, you are familiar with a high voltage and low current. This is an effect called static electricity, and even though there may be a potential of thousands of volts, there is such a small electron supply that the result is a harmless, if painful, surprise. This effect of high voltage, low current may be no problem.

If you've placed ordinary cell batteries in any portable device such as a large flashlight or a "boom box," you're aware that these devices must use a fairly large amount of current, yet there is no risk of shock, because the battery voltage is so low. This effect of low voltage, high current may be no problem.

An electric shock in a simple household setting can be injurious or even fatal due to the fact that the voltage is high enough to push electrons through the human body, while available current is also high enough to cause heating of tissue cells to the point of destruction. Electrical accidents in or around a consumer's home can be the most tragic of family events, yet are also often avoidable or preventable with proper household electrical wiring and care. Modern wiring components and installations are designed with accident avoidance in mind.

So what's a Stray Voltage?

The phenomenon of "stray" voltage is applied to any situation where some value of voltage can be measured between two points where there really should not be any significant reading. In a hazardous situation, this might be found between your stove and refrigerator, between your sink and bathroom floor, between your hot tub and room light switch, or between your house and your garage. If the voltage is fairly steady and even substantial enough to be felt, it probably means there is a fault somewhere in your house electrical system. And, yes, it could sometimes also mean that there is a faulty source of electrical energy outside your house. Situations of this type have been in the news from time to time.

Isn't it the power company's job to make sure electricity is safe?

It is indisputable that the electric utility must install and maintain its wiring and equipment in compliance with national industry standards, and with current laws and regulations. It is also true that all housing and building installations must be compliant with such legal and safety requirements as are in effect for the area of the construction. The problems can arise from errors during construction, or when equipment or wiring is added, modified or repaired, and as system components age or degrade over time. This situation can occur in both the utility's and the homeowner's systems, with potentially serious consequences. Still, it remains the householder's responsibility to assure that there are no faults at the consumer's end of the electrical power system.

Where does my electricity come from?

This leads us to a discussion of the electrical system, especially the role of the "neutral" and "ground" connections. We'll start with the "hot" lines, the two insulated cables that are normally wrapped around an uninsulated neutral cable that are connected to your house. These insulated lines have a voltage that measures about 240 volts between them, and 120 volts from each of them to the neutral. Remember, voltage is a relationship always between two points. The fact that our American system uses Alternating Current (AC) at 60 Hertz is not critical to this part of the discussion.

The neutral cable is normally connected with a "ground" rod at both the utility's transformer that supplies the power to your house, and at the electrical meter mounted on or close to your house. These ground rods are driven deep into the earth, and are to provide a safe "ground plane" to which the voltage at all other local electrical parts and connections should be referenced. This means that if you were to stick one probe from a voltmeter anywhere into the ground, the voltage read from the other probe at any other point in the ground or neutral wires ought to be equal to zero. In practicality, small voltages can sometimes appear between ground points for various reasons, but these should never be sufficient to feel a shock if the system is operating correctly.

Now from the electric meter, three service cables enter your house where there must be a circuit breaker or fuse box protecting your household wiring. All of your home wiring is run from this box. Besides the circuit-interrupting devices, there is also a neutral bus bar and a ground bus bar. The neutral and ground bus bars should be connected to each other, but they do not perform the same purpose. The ground bar should have a separate large bare cable running to a ground rod nearby. Each 120-volt household wiring cable should have an insulated wire connected to a circuit-interruption device, either a breaker or a fuse, depending on the type of installation. Each cable should also have another insulated wire connected to the neutral bar. A third wire, normally uninsulated, is to connect to the ground bar bar. For cables supplying 240-volt power to larger appliances, such as a clothes dryer, there will be another insulated wire connected to a circuit breaker which is specially paired with the first wire, forming a double-pole breaker.

In addition to the neutral connections to the ground rod at your meter box, your house should also have ground terminals at all electrical plug-in outlets and large appliances that are also connected by separate wires to the ground terminal bus bar in the service entrance box.

Now, to use any electric device, a lamp, a motor, a TV set, you must connect the device to both power and return conductors in the system. Normally, for example, an electric light will connect from one “hot” line to the neutral. The neutral serves as a return path for electricity running all the way from the utility transformer’s hot line through the device and back to the transformer. This is called a closed circuit. The ground leads that are tied to the neutral line only serve to stabilize or equalize the system, and should carry no current. This is important: in a properly-operating system, the ground circuit should **never** carry current! If there is ground current flowing, this nearly always means trouble.

What is happening during an accident?

When something goes wrong, electricity is flowing by way of an alternate path from its proper circuit. Where this alternate path takes the current flow through some area where it causes damage, such as through a human body or a flammable material, disaster can be the result. Wet locations tend to be more dangerous for people because moisture improves electrical conductivity or reduces resistance to current flow in materials that shouldn’t carry electric current, such as concrete or earth.

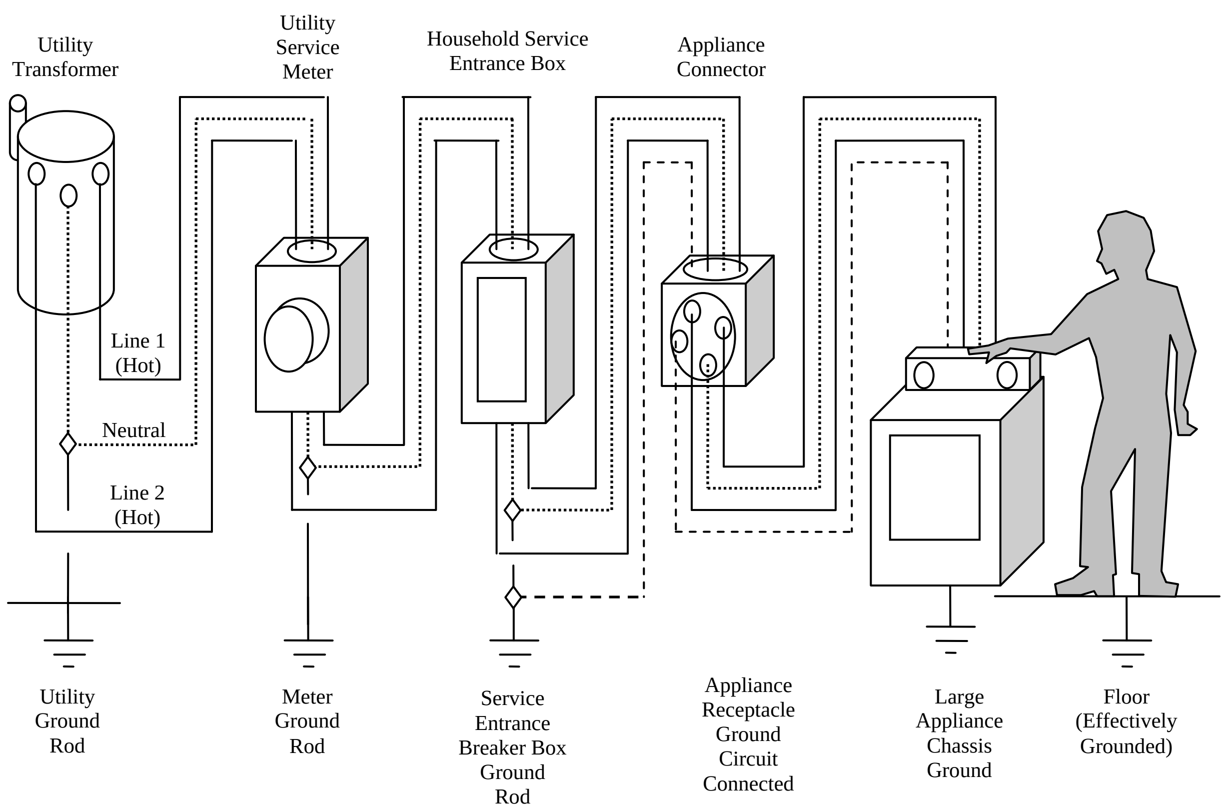
Where does the electricity go during an accident?

In a safely operating system, all working current flow is via the hot line and neutral wires. When a circuit is faulted, voltage from a hot wire is somehow able to be present at a place where it doesn’t belong. If anything contacts this energized place and provides an abnormal return path to neutral, it completes a circuit, and current flows. This fault current is what causes injury and does the damage. Ideally, fault current should be safely shunted to ground until it operates a safety device such as a fuse or circuit breaker. Another protective device specifically designed around ground currents, especially for wet or damp locations, is called a Ground-Fault Circuit Interrupter, or GFCI.

What is a GFCI?

When it comes to wet floors, it's a good idea to start talking about GFCI receptacles for normal household service. A Ground-Fault Circuit Interrupter (GFCI) is a modern safety device which will interrupt the power to an outlet when it detects current flow through the ground wire. Remember from above that the ground circuit should never carry current during normal safe conditions; all return operating current should flow through the neutral wire. A GFCI is usually installed in areas that are more prone to risk, such as wet, damp or outdoor locations. You should have GFCIs installed at electric outlet receptacles in bathrooms and basements, and around such installations as swimming pools, hot tubs, or boat docks. These devices are **not** absolutely foolproof for all types of failures! They can only shut off power to their own circuit after a fault is detected, so they prevent a bad situation from continuing or getting worse. Learn more about GFCIs from the US Consumer Product Safety Commission at their website: http://www.cpsc.gov/cpscpub/pubs/99.html

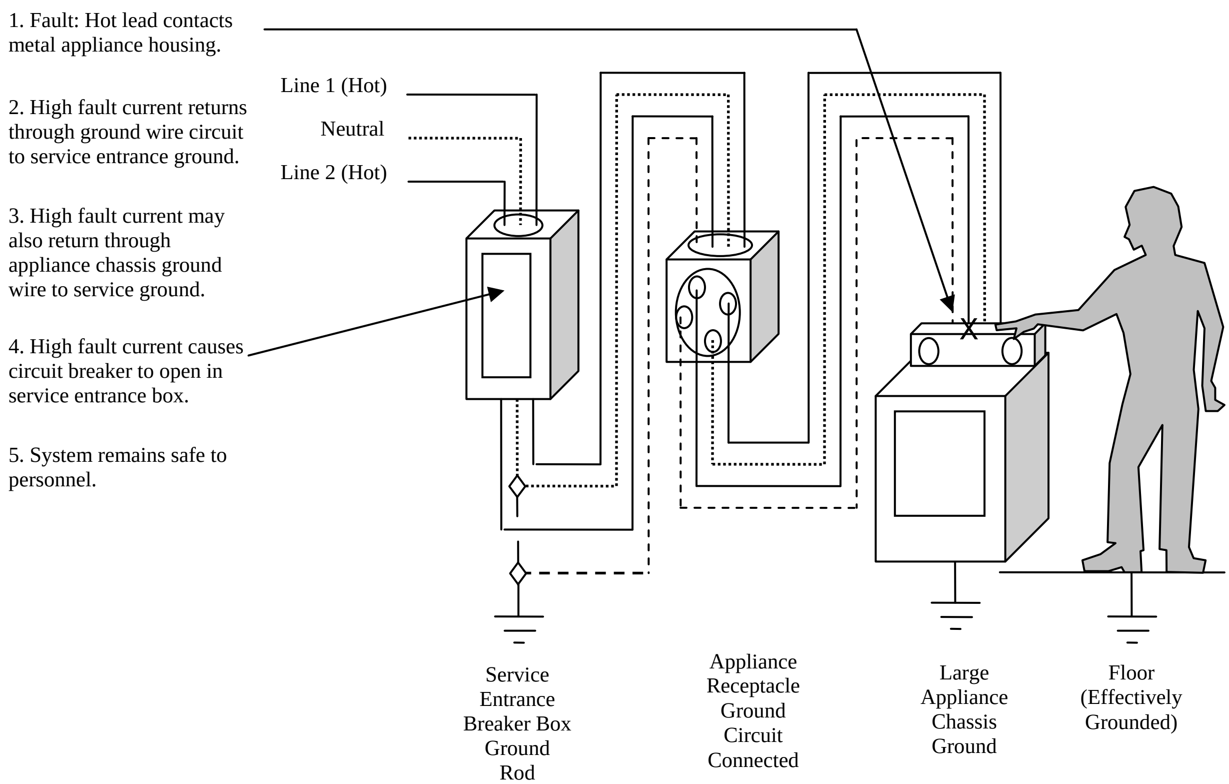
How about safely connecting large appliances?



This diagram shows a general arrangement showing the completed connections for operating a larger appliance that requires 240-volt service. There are two hot leads with 240 volts between them and a neutral return line running to the appliance. For safety, there are multiple ground points and a distinct ground circuit in the arrangement. Not only is there a separate lead running from the dedicated receptacle to the service box ground bus, but an additional wire is usually connected from the appliance's metal housing to some nearby ground point, such as a metal water pipe or a grounded metal electrical box. With no faults in the system, a person standing on a wet floor should be safely at the same electrical potential as the appliance housing.

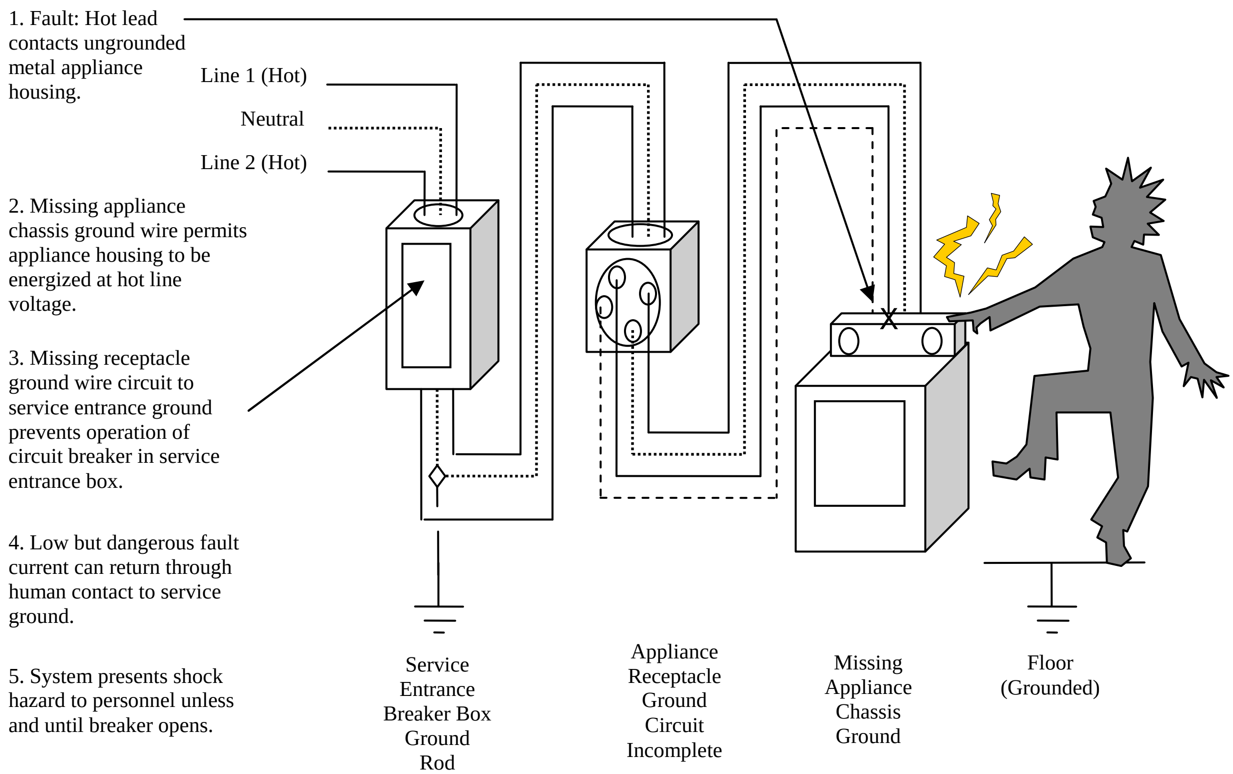
Can proper wiring prevent injury during a fault?

This diagram illustrates a fault event which should result in no injury due to the presence of proper circuitry. If a hot lead should come into contact with a metal casing, a neutral, or a ground lead, potentially dangerous current flow will cause safety device operation, shutting off all power to the appliance.



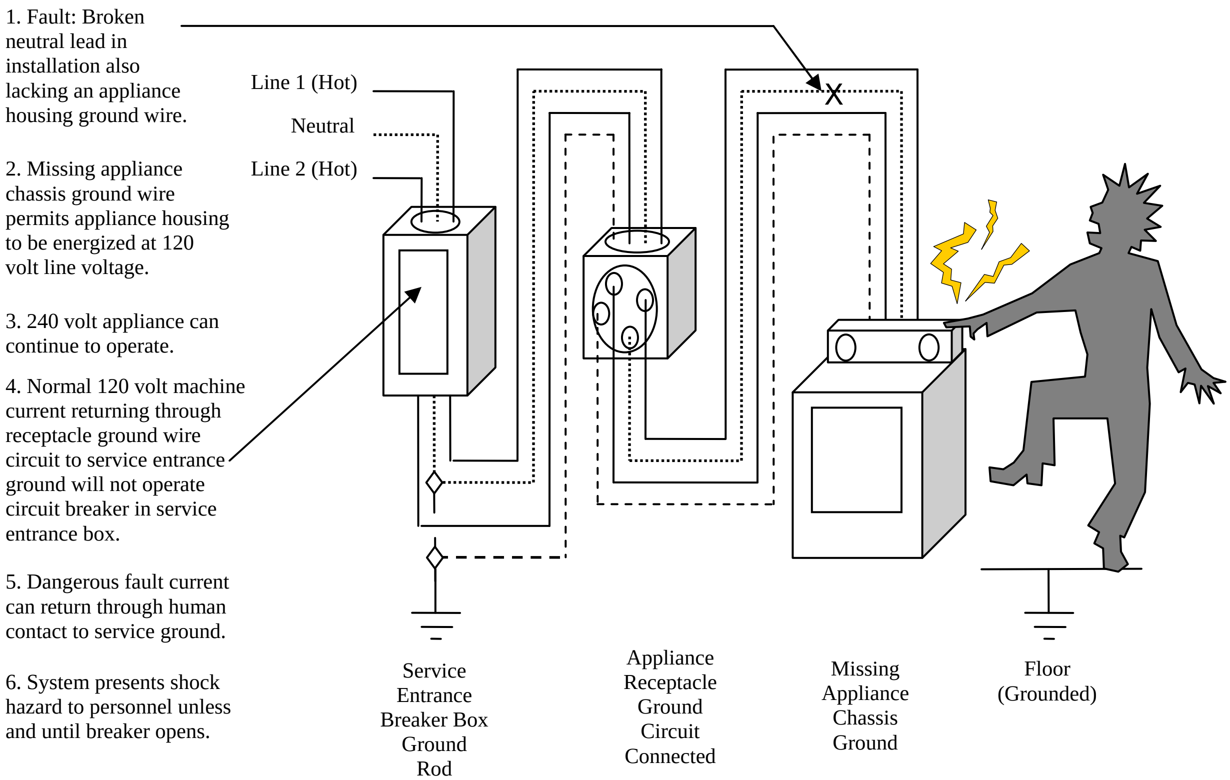
What kind of fault can result in an injury accident?

As a practical example, a once-common wiring configuration for electric clothes dryers led to an unusual hazard when a new dryer was installed. Older dryers used a three-wire cord and receptacle, whereas a change in electrical codes led to newer designs with four-wire circuits. The four-wire configuration allows separate leads for the neutral and ground circuits. Often when installing the newer dryers, the old wiring to the replacement receptacle had no ground wire, so the new receptacle’s ground terminal remained unconnected. The result was an increased risk for the incomplete installation with certain types of fault. The absence of a connection from the ground lug in a receptacle back to the ground bus bar in the service entrance box can establish a condition that offers a risk to personnel during a worst-case scenario as illustrated in the following diagram.



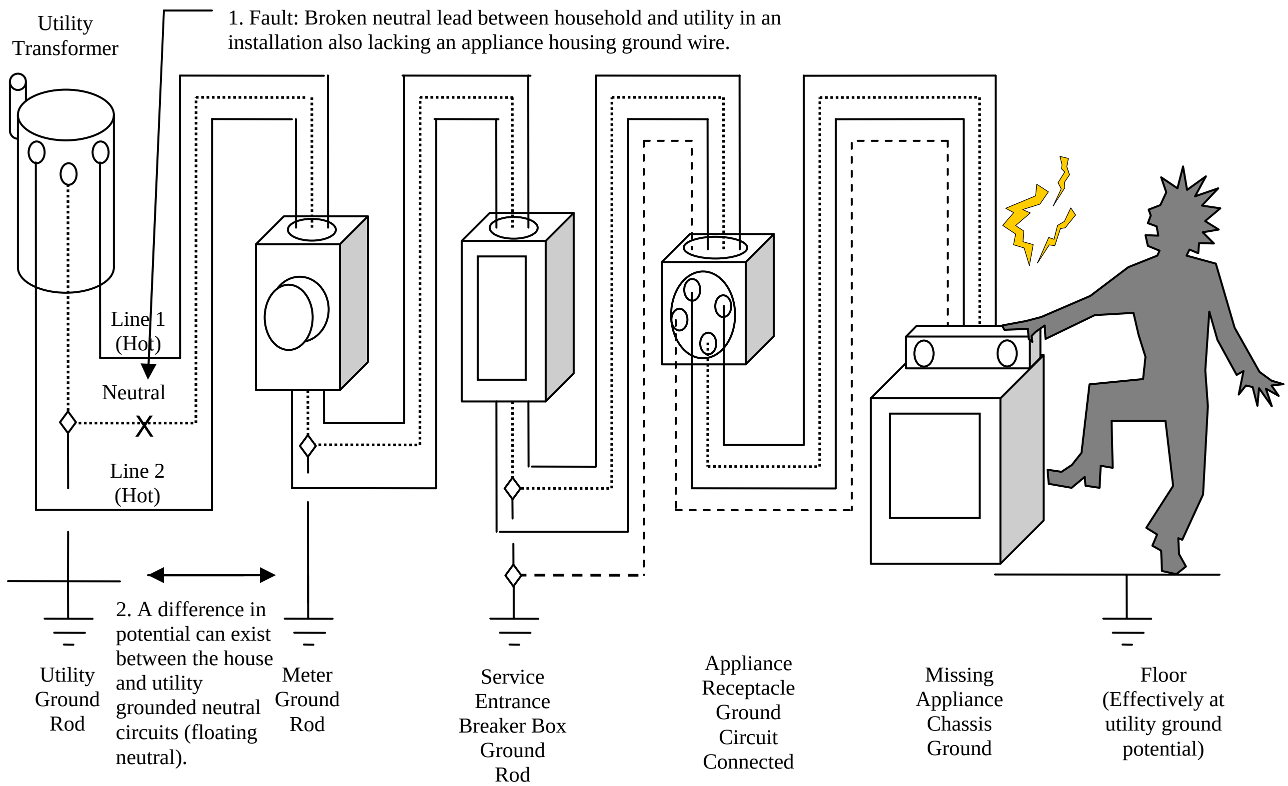
What kind of accident might occur even with proper wiring?

Even with hard-wired ground circuits intact, it's possible to create a scenario in which a shock hazard can arise. The loss of a connection to neutral inside an appliance, for example, can produce misdirected power return current, with attendant shock risk. 240-volt equipment can continue to run without a neutral path, whereas 120-volt control and lamp circuit currents in such a machine will return through the ground wires. These normal 120-volt currents will not be high enough to trip the circuit breaker in the service entrance box. Meanwhile, the grounding circuit allows 120-volt energy to be available at normally grounded locations, such as at the receptacle box or the appliance housing. This is due to the resistance normally present in any wired circuit, causing a voltage differential to appear between the machine and service ground rod. Not unless or until current drawn through the ground becomes abnormally high will the breaker open. Otherwise, fault current available at the machine housing may find another route, which could be through a human body. Such fault current might still not get high enough to open the breaker, but still deliver a serious shock. The means to prevent such an event is the wire connecting the machine's structure to a nearby solid ground point, such as a metal water pipe. By such a path, dangerous voltage would be shunted through to the near ground, protecting personnel standing in that area. A possible situation where the chassis ground is absent with such a faulted neutral arrangement can be seen below.



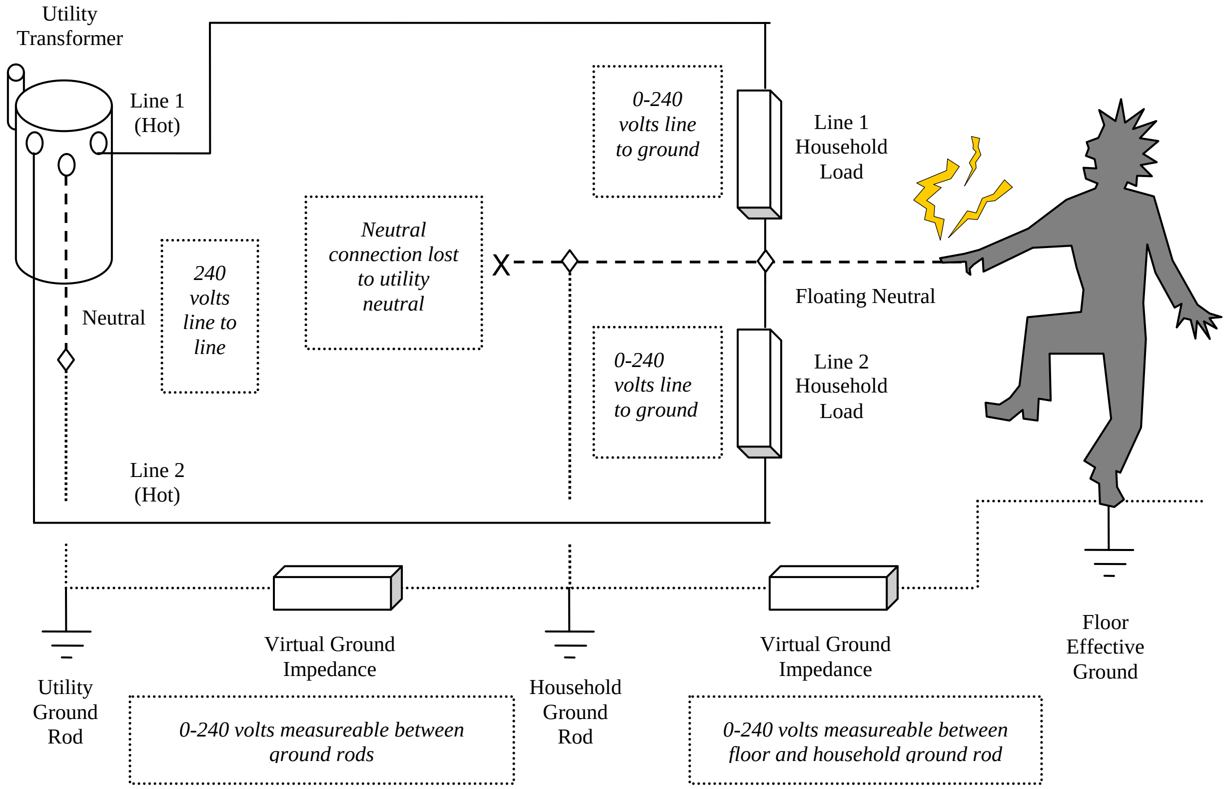
So what kind of fault can result in a Stray Voltage accident?

Accidents related to faulty wiring can result from the loss of a connection to neutral, or connecting the ground lug in a receptacle to its neutral terminal, or failing to connect a ground lug in any device to a suitable termination. The loss of a connection to the utility's neutral can then produce misdirected power return current from an energized device. A possible arrangement with a faulty current path is illustrated below. The loss of a connection in the utility's neutral can produce misdirected power return current from an energized system through any connected devices. All neutral current from operating equipment is then forced to return to the utility power system by way of ground paths. Stray voltages become ever more apparent when there can be found higher resistances and greater distances between ground points and the utility ground. The shock injury occurs when personnel complete an electrical connection between two ground points with substantial electrical separation.



How can a floating neutral cause damage even where the system seems to be correctly grounded?

A hazard can be created when the neutral path is disrupted due to such causes as corrosion or accidental physical damage. Without a direct connection from a household neutral back to the utility neutral, a risk of shock can appear at any point in the household circuit as return current tries to find a return path by some other way. Such a path can usually be found through the ground and grounding circuits. This path can include a human body wherever conductive points are separated from each other by distance or materials, and the body forms a connection between such points. The primary concept one should understand is that electric voltage depends on the **electrical separation** between points. A potential accident situation is illustrated below, where a hazard is due to stray voltage appearing across the natural, or virtual ground, impedance to current flow that will always be present through soil, water, or building materials. The household loads are composed of all of those regular 120 volt devices that are operating, such as clocks, lights, TV sets, radios, battery chargers, and small motors as in refrigerators and fans. The mix of which of these devices are plugged in and running will determine whether the load on a hot lead is higher or lower, and therefore will cause the voltage measured across them to be correspondingly higher or lower. The fact that there is no direct connection back to the neutral of the supply transformer means that the household neutral can be at a differing voltage, or "floating" relative to the utility's neutral. This in turn means that the voltage at the household neutral and ground points can be any value between the two line voltages of 240 volts, relative to the hot lines. It becomes possible then for 240 volts to appear, for example, across the plug of a clock or lamp. If the voltage across a device is the incorrect value for the device due to the "floating" effect of the neutral, while higher current can still flow, it can be damaged. Small appliance damage can result from higher-than-designed voltage breaking down the electrical insulation inside. Other damage can result in electric motors for example, due to lower-than-designed voltage drawing abnormally high current flow in the windings, creating excessive heating that burns out the motor.



So how can we avoid a Stray Voltage accident?

The key to avoiding any shock is to assure that any conductive objects a person is touching simultaneously are all electrically connected together, or "bonded." If there is no connection provided by a grounding circuit, it becomes possible for a voltage difference to appear between the objects. If this voltage is high enough, it can push power current through the person's body as the current finds a return path back to the energizing system. The safest solution is to always have a wired ground path between any metal or wet parts that are close enough for someone to touch.

So what's the bottom line?

In the end, you should know that electricity can be dangerous, tricky and treacherous stuff. If you have any reason to believe you're getting shocked, you should promptly consult a competent professional person to test and evaluate your household system. These tests should not overlook the grounding and bonding connections at your service entry and the general appearance of the utility's meter and any visible parts. Other than that, it will be up to the utility to verify that its own system is operating properly and safely. The PSC will be available if you feel the need to file a complaint concerning your electric service.